ENVIRONMENTAL RESEARCH 59, 271–278 (1992)

A Retrospective Mortality Cohort Study of Chrysotile Asbestos Products Workers in Tianjin 1972–1987

WEI-NAN CHENG* AND JIAN KONG†

*Tianjin Medical College, Tianjin, China 300070; and †National Institute of Vaccine & Serum, Beijing, China

Received May 15, 1992

The mortality rate of a cohort of asbestos workers was investigated in Tianjin, China, between January 1, 1972, and December 31, 1987. The cohort consisted of 662 males and 510 females, employed in asbestos textiles, friction material, and asbestos cement manufacturing. A statistically significant excess mortality was observed for lung cancer in both males and females (SMR 278 and 427, respectively). An increasing trend in SMR was observed with increasing intervals of exposure as well as with increasing exposure level. A synergistic effect was seen between asbestos exposure and cigarette smoking regarding lung cancer. The ratio of smoking and nonsmoking lung cancer death rates was virtually the same in asbestos and in nonasbestos workers. This ratio was approximately 1.6, a value much less than that reported in other countries. This low ratio appears to reflect the fact that many nonsmokers were in fact passive cigarette smokers. Second, it reflects the fact that most smokers smoked hand-rolled tobacco, since manufactured cigarettes did not become popular in China until 1965. These data confirm the hazards of asbestos exposure in developing countries. © 1992 Academic Press, Inc.

INTRODUCTION

The high prevalence of carcinoma in workers exposed to asbestos and the increased incidence of lung cancer in particular are very well known (for example, 623 New York–New Jersey insulators, 17,800 United States–Canada insulators, 933 Amosite factory workers, and 689 asbestos factory workers). Preliminary results from the cohorts established by Selikoff and his colleagues at Mount Sinai (Selikoff *et al.*, 1970, 1979, 1980; Selikoff and Lee, 1978) support this finding. We show that the death rate from lung cancer is much higher than would be expected among persons of similar age not employed in the asbestos trade. To date, more than 30 cohorts studies have been carried out among asbestos workers in several countries.

An asbestos industry has developed since the 1950s in China. This is a report of a cohort study in 1987 in an asbestos product factory in Tianjin.

METHODS

In 1955 this factory was formed by merging several small asbestos plants founded before 1949. There are five workshops (carding, twisting, friction material, cement, and maintenance).

The members of the cohort were workers who were employed in the Tianjin

0013-9351/92 $5.00
Copyright © 1992 by Academic Press, Inc.
All rights of reproduction in any form reserved.

PM3000456484

Source: https://www.industrydocuments.ucsf.edu/docs/lpcl0001

TABLE 1
CONCENTRATION (MG/M^3) OF ASBESTOS DUST BY WORKSHOP

Workshop and job	Mean concentration of asbestos dust		Concentration of asbestos through 1975–1979, 1982, and 1986	
	1964	1974	Medium	Range
Carding and spinning				
Milling	22.5	16.7	14.7	2.9–23.3
Mixing	34.5	12.7	10.2	1.8–15.3
Carding	—	—	6.2	2.2–26.1
Roving	37.5	39.4	1.2	0.3–8.9
Spinning	—	4.3	3.9	0.3–8.6
Twisting				
Universal winding	12.6	3.2	2.4	1.3–3.1
Braiding	8.3	3.8	2.3	0.6–3.5
Foster winding	12.2	9.2	8.7	2.2–10.3
Braided rope	8.3	4.7	3.7	0.5–4.8
Friction material				
Grinding	22.5	24.3	3.8	1.2–29.8
Mixing	—	20.2	10.5	1.8–19.5
Crushing	—	88.8	2.8	1.9–3.5
Cutting	—	72.3	58.4	4.2–75.9
Inspection	32.0	—	22.3	11.8–22.3
Hot Pressing	—	4.6	4.2	3.2–5.1
Cement				
Milling	41.4	23.8	20.8	8.7–30.3
Crushing	34.2	24.2	14.6	12.8–28.5
Mixing	166.6	39.6	20.0	4.3–42.4

TABLE 2
DISTRIBUTION OF PERSONS BY AGE AND SEX AMONG ASBESTOS WORKERS

Age groups	Male	Female	Total
15–19	80	74	154
20–24	39	37	76
25–29	102	105	207
30–34	51	83	134
35–39	81	103	184
40–44	72	47	119
45–49	86	21	107
50–54	72	12	84
55–59	51	8	59
60–64	16	9	25
65–69	6	6	12
70–74	4	4	8
75–79	1	0	1
80+	1	1	2
Total	662	510	1172

PM3000456485

Source: https://www.industrydocuments.ucsf.edu/docs/lpcl0001

TABLE 3
PERSON-YEARS: DEATHS FROM ALL CAUSES AND FROM TOTAL CANCER

	Person-years			Total deaths			Total cancer deaths		
Age	Male	Female	Total	Male	Female	Total	Male	Female	Total
15	114.38	108.82	223.20	0	0	0	0	0	0
20	513.77	417.41	931.18	0	0	0	0	0	0
25	870.44	836.02	1706.46	2	0	2	0	0	0
30	1203.79	1253.36	2457.15	0	1	1	1	0	1
35	1071.00	1362.21	2433.21	3	1	4	0	1	1
40	1126.09	1398.39	2524.48	6	1	7	1	0	1
45	1088.27	1078.98	2167.25	12	5	17	2	4	6
50	1171.85	696.01	1867.86	16	4	20	3	2	5
55	1061.34	315.32	1376.66	25	2	27	10	1	11
60	808.27	149.70	957.97	21	5	26	8	3	11
65	459.54	108.86	568.40	18	3	21	2	2	4
70	204.78	82.38	287.16	8	4	12	3	0	3
75	50.47	46.51	96.98	3	6	9	0	0	0
80	22.43	26.24	48.67	1	2	3	0	1	1
85	4.00	7.41	11.41	1	1	2	0	0	0
90	0.00	0.01	0.01	0	0	0	0	0	0
Total	9770.42	7887.63	17,658.05	116	35	151	30	14	44

asbestos products factory on January 1, 1972, and had been exposed to asbestos for at least 1 year by that time. There were 1,172 individuals in the cohort (662 men and 510 women).

An employment card indicated each worker's name, date of birth, sex, marital status, address, and a detailed work history. Deaths from all malignant tumors were diagnosed by radiographic or pathological evidence.

Exposure levels were divided into three ranks as follows:

High—workers who worked in carding, spinning, friction material, or cement at least 1 year before 1974.

Middle—who worked less than 1 year at high-exposure level locations before 1974 and worked in other workshops 5 years, or more than 10 years in high-exposure level workshops after 1974.

Low—workers who worked in the twisting workshop or in the other workshops less than 10 years after 1974.

Any subject that smoked one or more cigarettes per day for at least 1 year was considered a smoker. The smoker's history was determined by the following data: number of cigarettes smoked each day, beginning smoking age, and number of years smoking.

Concentration of dust was measured by weight in mg/m^3.

RESULTS

Large changes in the concentration of asbestos dust occurred after 1974 be-

PM3000456486

Source: https://www.industrydocuments.ucsf.edu/docs/lpcl0001

TABLE 4
ALL CAUSES OF DEATH COMPARED WITH MORTALITY RATE OF TIANJIN POPULATION

Cause of death	Male			Female			Total		
	Observed	Expected	SMR	Observed	Expected	SMR	Observed	Expected	SMR
Total death	116	89.84	129*	35	40.71	87	151	130.55	116*
Total cancer	30	21.30	141	14	7.04	199*	44	28.34	155*
Lung	14	5.03	278*	7	1.64	427*	21	6.67	315*
Stomach	7	5.57	126	0	1.78	—	7	6.35	110
Liver	5	5.00	100	0	1.66	—	5	6.66	75
Breast	0	—	—	3	0.25	—	3	0.25	—
Other	4	5.70	70	4	1.71	—	8	7.41	108
Diseases of circulatory system	36	49.58	73*	9	18.78	48*	45	68.36	66*
Cerebrovascular	26	23.18	112	4	9.93	—	30	33.11	91
Pulmonary Tuberculosis	9	4.23	212*	2	2.28	—	11	6.51	169
Asbestosis	5	—	—	0	—	—	5	—	—
Other respiratory diseases	20	7.70	259*	9	4.08	220*	29	11.78	246*
Diseases of digestive system	7	7.86	89	0	—	—	—	—	—
Accident	6	4.32	138	1	1.44	—	7	5.76	122
Others	3	1.94	—	0	—	—	—	—	—

* $P < 0.05$.

PM3000456487

Source: https://www.industrydocuments.ucsf.edu/docs/lpcl0001

TABLE 5
OBSERVED AND EXPECTED LUNG CANCER DEATHS BY LAPSED TIME SINCE INITIAL EXPOSURE

Years since initial exposure	Deaths		SMR
	Observed	Expected	
<20	2	0.48	—
20–	14	4.50	311**
35–	5	1.68	297*

* $P < 0.05$.
** $P < 0.01$.

cause of equipment changes and installation of exhaust ventilation at some operations. The mean concentration of asbestos dust in 1964 and 1974 and the medium concentrations of asbestos dust (1975–1979, 1982 and 1986) are shown in Table 1.

The distribution of persons by age and sex among asbestos workers in 1972 is shown in Table 2.

The average age of death from all causes was 59.45 and 58.45 for men and 62.78 for women. The average age of death from cancer at all sites was 56.95 and 57.5 for men and 55.78 for women.

The person-years deaths from all causes and cancer are shown in Table 3.

The causes of death and SMRs are shown in Table 4.

Observed and expected lung cancer deaths by lapsed time since initial exposure are shown in Table 5. The longer the period of time since the initial exposure, the higher the risk a worker dying from lung cancer; but the risk 35 years after initial exposure is lower than that between 20 and 35 years. The observed and expected lung cancer deaths by duration of exposure are shown in Table 6.

Table 7 shows the observed and expected lung cancer death by exposure level and cumulative exposed dose.

The observed and expected lung cancer deaths for asbestosis and nonasbestosis are shown in Table 8.

Table 9 shows the relationship between lung cancer and asbestosis, OR = 2.597, $P < 0.05$. There seems to be a relationship between lung cancer and asbestos

Lung cancer by asbestosis and by exposure level is shown in Table 10.

TABLE 6
OBSERVED AND EXPECTED LUNG CANCER DEATHS BY DURATION OF EXPOSURE

Years of exposure	Deaths		SMR
	Observed	Expected	
1–14	5	2.27	220
15–	11	3.64	302**
30–	5	0.75	667**

** $P < 0.01$.

PM3000456488

Source: https://www.industrydocuments.ucsf.edu/docs/lpcl0001

TABLE 7
OBSERVED AND EXPECTED LUNG CANCER DEATHS BY EXPOSURE LEVEL AND CUMULATIVE EXPOSED DOSE

Exposure level	Deaths		SMR	Cumulative dose (mg/m^3 yr)	Deaths		SMR
	Observed	Expected			Observed	Expected	
Low	0	1.07	—	<400	10	3.42	289**
Middle	8	2.32	345**	400–	6	2.21	271**
High	13	3.28	396**	800–	5	1.03	485**

** $P < 0.01$.

The relationship between smoking and lung cancer is shown in Table 11.

The ratio of lung cancer deaths among cigarette smokers to that among nonsmokers in the control group was 1.57 and that in the asbestos-exposed group was 1.6.

The ratio of lung cancer deaths of nonsmokers with asbestos exposure to those without asbestos exposure was 5.44. The ratio of lung cancer deaths of smokers with asbestos exposure to those without asbestos exposure was 5.54.

DISCUSSION

The principal finding of this investigation was a strong relationship between lung cancer and asbestos exposure among asbestos workers in China. Dose–response relationships were seen between lung cancer mortality and (1) intense exposure, (2) duration of exposure, (3) lapsed time since initial exposure, and (4) cumulative asbestos dust exposure. These findings are similar to those observed in the cohorts of asbestos workers studied at Mt. Sinai by Selikoff and colleagues as well as by authors in other nations.

A synergistic effect between asbestos and cigarette smoking was observed. Our findings in this regard are similar to those observed by Selikoff *et al.* However, there is an important difference between our findings and those observed in Western countries; the ratio of smoking and lung cancer deaths is substantially lower than that in most nations—approximately 1.6. This low ratio of lung cancer mortality among smokers to that among nonsmokers appears to reflect two factors: (1) most nonsmokers were in fact passive smokers, because cigarette smoking is

TABLE 8
OBSERVED AND EXPECTED LUNG CANCER DEATHS IN ASBESTOSIS AND NONASBESTOSIS

Asbestosis	Deaths		SMR
	Observed	Expected	
Yes	13	4.07	3.20**
No	8	2.61	3.06*

* $P < 0.05$.
** $P < 0.01$.

PM3000456489

Source: https://www.industrydocuments.ucsf.edu/docs/lpcl0001

TABLE 9
THE RELATIONSHIP BETWEEN LUNG CANCER AND ASBESTOSIS

Asbestosis	Lung cancer Yes	Lung cancer No
Yes	13	443
No	8	708

Note. OR = 2.597; 95% CL = 1.07–6.32.

highly prevalent in China and rooms tend to be small; (2) the tobacco smoke intake of most smokers was relatively low, because until 1965, manufactured cigarettes were not available in China and most smokers were able to use only hand-rolled cigarettes.

CONCLUSION

An asbestos industry has developed in China since the 1950s. During this 40-year period, a strong effect of asbestos exposure on lung cancer mortality has been observed among asbestos workers in China.

Lung cancer mortality among Chinese workers is related to (1) intensity of exposure, (2) duration of exposure, (3) lapsed time since initial exposure, and (4) cumulative asbestos dust exposure.

A relationship was observed between lung cancer and asbestos. These findings are similar to those of many other authors (Enterline *et al.*, 1967; Sluis-Cremer, 1980; Cooperative Research on Cancer Caused by Asbestos, 1987).

Asbestos was found to play a synergistic role with cigarette smoking in the causation of lung cancer.

Nonmalignant pulmonary diseases (including asbestosis and tuberculosis) are still the major cause of death in China at present. Lung cancer mortality, however, is anticipated to increase in the future as a consequence of exposure to both asbestos and cigarette smoke.

Preventive efforts should focus on reduction of occupational and environmental exposure to asbestos as well as smoking cessation.

TABLE 10
LUNG CANCER BY ASBESTOSIS, EXPOSURE LEVEL

Exposure level	Lung cancer Yes	Lung cancer No	Total
Middle			
Yes	4	160	164
No	4	269	273
High			
Yes	9	231	240
No	4	242	246

PM3000456490

Source: https://www.industrydocuments.ucsf.edu/docs/lpcl0001

TABLE 11
LUNG CANCER DEATH RATES 20 OR MORE YEARS FROM ONSET OF EXPOSURE IN RELATION TO CIGARETTE SMOKING

Group	Asbestos exposure	Cigarette smoking	Death rate	Mortality ratio
Control[a]	No	No	38.27	1.00
Asbestos workers	Yes	No	208.23	5.44
Control[a]	No	Yes	60.31	1.57
Asbestos workers	Yes	Yes	334.24	8.73

Note. Death rate based on deaths per 100,000 person-years standardized for age and smoking habits.
[a] Control: 3219 workers not exposed to asbestos or to dust, fumes, or vapor.

REFERENCES

Bjorn Hilt, *et al.* (1985). Asbestos exposure, smoking habits and cancer incidence among production and maintenance workers in electrochemical plant. *Am. J. Ind. Med.* 8, 565.

Cooperative Research on Cancer Caused by Asbestos (1987). A retrospective cohort study on asbestos products factory. *Chinese Ind. Hyg. Occup. Dis.* 5, 29.

Dement, J. M. (1982). Estimates of dose–response for respiratory cancer among chrysotile asbestos textile workers. *Ann. Occup. Hyg.* 26, 869.

Enterline, P. E., *et al.* (1967). Asbestos dust exposures at various levels and mortality. *Arch. Environ. Health* 15, 181.

Hughes, J. M., *et al.* (1987). Mortality of man employed in two asbestos cement manufacturing plant. *Br. J. Ind. Med.* 44, 161.

Peto, J., *et al.* (1985). Relationship of mortality to measure of environmental asbestos pollution in asbestos textile factory. *Ann. Occup. Hyg.* 29, 305.

Selikoff, I. J., and Lee, D. H. K. (1978). "Asbestos and Disease." pp. 307–336. Academic Press, New York/San Francisco/London.

Selikoff, I. J., *et al.* (1970). Mortality experience of asbestos insulation workers, 1943–1968. *Pneumoconiosis 3rd Proc. Int. Conf.*, 180.

Selikoff, I. J., *et al.* (1980). Asbestos exposure, smoking, and neoplasia. *J. Am. Med. Assoc.* 37, 11.

Selikoff, I. J. (1979). Mortality experience of insulation workers in the United States and Canada, 1943–1976. *Ann. NY Acad. Sci.* 330, 91.

Sluis-Cremer, G. (1980). The relationship between asbestosis and bronchial cancer. *Chest* 78 (suppl), 380.

PM3000456491

Source: https://www.industrydocuments.ucsf.edu/docs/lpcl0001